

AMENDMENTS TO THE CLAIMS

1. (currently amended) A cabin communication system for improving clarity of a voice spoken within an interior cabin having ambient noise, said cabin communication system comprising:

a microphone for receiving the spoken voice and the ambient noise and for converting the spoken voice and the ambient noise into an audio signal, the audio signal having a first component corresponding to the spoken voice and a second component corresponding to the ambient noise;

a speech enhancement filter for removing the second component from the audio signal to provide a filtered audio signal, said speech enhancement filter removing the second component by processing the audio signal by a method ~~taking into account elements of psycho-acoustics of a human ear~~ responsive to the way the human ear perceives sound at different frequencies on a non-linear mel-scale; and

a loudspeaker for outputting a clarified voice in response to the filtered audio signal.

2. (canceled)

3. (currently amended) The cabin communication system of claim 2 ~~1~~, wherein said speech enhancement filter ~~takes the one element into account by smoothing~~ smoothes a spectrum of the audio signal over larger windows at higher frequencies.

4. (currently amended) The cabin communication system of claim 1, wherein ~~one of the elements of psycho-acoustics taken into account is~~ the method is further responsive to the way that speech is anti-causal and noise is causal.

5. (currently amended) The cabin communication system of claim 4, wherein said speech enhancement filter ~~takes the one element into account by filtering~~ filters the audio signal with a causal filter.

6. (original) The cabin communication system of claim 5, wherein said causal filter is a causal Wiener filter.

7. (original) The cabin communication system of claim 6, wherein said causal Wiener filter takes a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

8. (original) The cabin communication system of claim 1, wherein said speech enhancement filter uses temporal smoothing of a Wiener filter calculation.

9. (original) The cabin communication system of claim 1, wherein said speech enhancement filter uses frequency smoothing of a Wiener filter calculation.

10. (original) A cabin communication system for improving clarity of a voice spoken within an interior cabin having ambient noise, said cabin communication system comprising:

a microphone for receiving the spoken voice and the ambient noise and for converting the spoken voice and the ambient noise into an audio signal, the audio signal having a first component corresponding to the spoken voice and a second component corresponding to the ambient noise;

a speech enhancement filter for removing the second component from the audio signal to provide a filtered audio signal; and

a loudspeaker for outputting a clarified voice in response to the filtered audio signal,

wherein said speech enhancement filter comprises:

a first filter element that smooths a spectrum of the audio signal over larger windows at higher frequencies in accordance with a mel-scale to provide a smoothed audio signal;

a second filter element that filters the smoothed audio signal with a causal Wiener filter to provide a Wiener filter result; and

a third filter element that performs at one of temporal and frequency smoothing of the Wiener filter result to provide the filtered audio signal.

11. (original) The cabin communication system of claim 10, wherein said second filter element provides the Wiener filter result by taking a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

12. (original) The cabin communication system of claim 11, wherein said third filter element performs both temporal and frequency smoothing of the Wiener filter result.

13. (original) A speech enhancement filter for improving clarity of a voice represented by an audio signal, said speech enhancement filter comprising:

a first filter element that smooths a spectrum of the audio signal over larger windows at higher frequencies in accordance with a mel-scale to provide a smoothed audio signal;

a second filter element that filters the smoothed audio signal with a causal Wiener filter to provide a Wiener filter result; and

a third filter element that performs at one of temporal and frequency smoothing of the Wiener filter result to provide a filtered audio signal corresponding to a clarified version of the spoken voice.

14. (original) The speech enhancement filter of claim 13, wherein said second filter element provides the Wiener filter result by taking a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

15. (original) The speech enhancement filter of claim 14, wherein said third filter element performs both temporal and frequency smoothing of the Wiener filter result.

16. (original) A movable vehicle cabin having ambient noise, said cabin comprising:

means for causing movement of said cabin, wherein at least a portion of the ambient noise during movement is a result of the movement; and

a cabin communication system for improving clarity of a voice spoken within an interior of said cabin, wherein said cabin communication system comprises:

a microphone for receiving the spoken voice and the ambient noise and for converting the spoken voice and the ambient noise into an audio signal, the audio signal having a first component corresponding to the spoken voice and a second component corresponding to the ambient noise;

a speech enhancement filter for removing the second component from the audio signal to provide a filtered audio signal, said speech enhancement filter removing the second component by processing the audio signal by a method taking into account elements of psycho-acoustics of a human ear; and

a loudspeaker for outputting a clarified voice in response to the filtered audio signal.

17. (original) The cabin of claim 16, wherein one of the elements of psycho-acoustics taken into account is that the human ear perceives sound at different frequencies on a non-linear mel-scale.

18. (original) The cabin of claim 17, wherein said speech enhancement filter takes the one element into account by smoothing a spectrum of the audio signal over larger windows at higher frequencies.

19. (original) The cabin of claim 16, wherein one of the elements of psycho-acoustics taken into account is that speech is anti-causal and noise is causal.

20. (original) The cabin of claim 19, wherein said speech enhancement filter takes the one element into account by filtering the audio signal with a causal filter.

21. (original) The cabin of claim 20, wherein said causal filter is a causal Wiener filter.

22. (original) The cabin of claim 21, wherein said causal Wiener filter takes a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

23. (original) The cabin of claim 16, wherein said speech enhancement filter uses temporal smoothing of a Wiener filter calculation.

24. (original) The cabin of claim 16, wherein said speech enhancement filter uses frequency smoothing of a Wiener filter calculation.

25. (original) A movable vehicle cabin having ambient noise, said cabin comprising:

means for causing movement of said cabin, wherein at least a portion of the ambient noise during movement is a result of the movement; and

a cabin communication system for improving clarity of a voice spoken within an interior of said cabin, wherein said cabin communication system comprises:

a microphone for receiving the spoken voice and the ambient noise and for converting the spoken voice and the ambient noise into an audio signal, the audio signal having a first component corresponding to the spoken voice and a second component corresponding to the ambient noise;

a speech enhancement filter for removing the second component from the audio signal to provide a filtered audio signal; and

a loudspeaker for outputting a clarified voice in response to the filtered audio signal,

wherein said speech enhancement filter comprises:

a first filter element that smooths a spectrum of the audio signal over larger windows at higher frequencies in accordance with a mel-scale to provide a smoothed audio signal;

a second filter element that filters the smoothed audio signal with a causal Wiener filter to provide a Wiener filter result; and

a third filter element that performs at one of temporal and frequency smoothing of the Wiener filter result to provide the filtered audio signal.

26. (original) The cabin of claim 25, wherein said second filter element provides the Wiener filter result by taking a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

27. (original) The cabin of claim 25, wherein said third filter element performs both temporal and frequency smoothing of the Wiener filter result.

28. (original) A cabin communication system for improving clarity of a voice spoken within an interior cabin having ambient noise, said cabin communication system comprising:

a first microphone, positioned at a first location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a first audio signal, the first audio signal having a first component corresponding to the ambient noise;

a second microphone, positioned at a second location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a second audio signal, the second audio signal having a second component corresponding to the ambient noise;

a processor for summing the first and second audio signals to provide a resultant audio signal that is indicative of a detection location within the cabin relative to the first and second locations of said first and second microphones;

a speech enhancement filter for filtering the resultant audio signal by removing the first and second components to provide a filtered audio signal;

an echo cancellation system receiving the filtered audio signal and outputting an echo-cancelled audio signal; and

a loudspeaker for converting the echo-cancelled audio signal into an output reproduced voice within the cabin including a third component indicative of the first and second audio signals,

wherein said loudspeaker and said first and second microphones are acoustically coupled so that the output reproduced voice is fed back from said loudspeaker to be received by said first and second microphones and converted with the spoken voice into the first and second audio signals,

wherein said echo cancellation system removes from the filtered audio signal any portion of the filtered audio signal corresponding to the third component, and

wherein said speech enhancement filter removes the first and second components by processing the resultant audio signal by a method taking into account elements of psycho-acoustics of a human ear.

29. (original) The cabin communication system of claim 28, wherein one of the elements of psycho-acoustics taken into account is that the human ear perceives sound at different frequencies on a non-linear mel-scale.

30. (original) The cabin communication system of claim 29, wherein said speech enhancement filter takes the one element into account by smoothing a spectrum of the resultant audio signal over larger windows at higher frequencies.

31. (original) The cabin communication system of claim 28, wherein one of the elements of psycho-acoustics taken into account is that speech is anti-causal and noise is causal.

32. (original) The cabin communication system of claim 31, wherein said speech enhancement filter takes the one element into account by filtering the resultant audio signal with a causal filter.

33. (original) The cabin communication system of claim 32, wherein said causal filter is a causal Wiener filter.

34. (original) The cabin communication system of claim 33, wherein said causal Wiener filter takes a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

35. (original) The cabin communication system of claim 28, wherein said speech enhancement filter uses temporal smoothing of a Wiener filter calculation.

36. (original) The cabin communication system of claim 35, wherein said speech enhancement filter uses frequency smoothing of a Wiener filter calculation.

37. (original) A cabin communication system for improving clarity of a voice spoken within an interior cabin having ambient noise, said cabin communication system comprising:

a first microphone, positioned at a first location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a first audio signal, the first audio signal having a first component corresponding to the ambient noise;

a second microphone, positioned at a second location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a second audio signal, the second audio signal having a second component corresponding to the ambient noise;

a processor for summing the first and second audio signals to provide a resultant audio signal that is indicative of a detection location within the cabin relative to the first and second locations of said first and second microphones;

a speech enhancement filter for filtering the resultant audio signal by removing the first and second components to provide a filtered audio signal;

an echo cancellation system receiving the filtered audio signal and outputting an echo-cancelled audio signal; and

a loudspeaker for converting the echo-cancelled audio signal into an output reproduced voice within the cabin including a third component indicative of the first and second audio signals,

wherein said loudspeaker and said first and second microphones are acoustically coupled so that the output reproduced voice is fed back from said loudspeaker to be received by said first and second microphones and converted with the spoken voice into the first and second audio signals,

wherein said echo cancellation system removes from the filtered audio signal any portion of the filtered audio signal corresponding to the third component, and

wherein said speech enhancement filter comprises:

a first filter element that smooths a spectrum of the resultant audio signal over larger windows at higher frequencies in accordance with a mel-scale to provide a smoothed audio signal;

a second filter element that filters the smoothed audio signal with a causal Wiener filter to provide a Wiener filter result; and

a third filter element that performs at one of temporal and frequency smoothing of the Wiener filter result to provide the filtered audio signal.

38. (original) The cabin communication system of claim 37, wherein said second filter element provides the Wiener filter result by taking a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

39. (original) The cabin communication system of claim 38, wherein said third filter element performs both temporal smoothing and frequency smoothing of the Wiener filter result.

40. (original) A movable vehicle cabin having ambient noise, said cabin comprising:

means for causing movement of said cabin, wherein at least a portion of the ambient noise during movement is a result of the movement; and

a cabin communication system for improving clarity of a voice spoken within an interior of said cabin, said cabin communication system comprising:

a first microphone, positioned at a first location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a first audio signal, the first audio signal having a first component corresponding to the ambient noise;

a second microphone, positioned at a second location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a second audio signal, the second audio signal having a second component corresponding to the ambient noise;

a processor for summing the first and second audio signals to provide a resultant audio signal that is indicative of a detection location within the cabin relative to the first and second locations of said first and second microphones;

a speech enhancement filter for filtering the resultant audio signal by removing the first and second components to provide a filtered audio signal;

an echo cancellation system receiving the filtered audio signal and outputting an echo-cancelled audio signal; and

a loudspeaker for converting the echo-cancelled audio signal into an output reproduced voice within the cabin including a third component indicative of the first and second audio signals,

wherein said loudspeaker and said first and second microphones are acoustically coupled so that the output reproduced voice is fed back from said loudspeaker to be received by said first and second microphones and converted with the spoken voice into the first and second audio signals,

wherein said echo cancellation system removes from the filtered audio signal any portion of the filtered audio signal corresponding to the third component, and

wherein said speech enhancement filter removes the first and second components by processing the resultant audio signal by a method taking into account elements of psycho-acoustics of a human ear.

41. (original) The cabin of claim 40, wherein one of the elements of psycho-acoustics taken into account is that the human ear perceives sound at different frequencies on a non-linear mel-scale.

42. (original) The cabin of claim 29, wherein said speech enhancement filter takes the one element into account by smoothing a spectrum of the resultant audio signal over larger windows at higher frequencies.

43. (original) The cabin of claim 40, wherein one of the elements of psycho-acoustics taken into account is that speech is anti-causal and noise is causal.

44. (original) The cabin of claim 43, wherein said speech enhancement filter takes the one element into account by filtering the resultant audio signal with a causal filter.

45. (original) The cabin of claim 44, wherein said causal filter is a causal Wiener filter.

46. (original) The cabin of claim 45, wherein said causal Wiener filter takes a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

47. (original) The cabin of claim 40, wherein said speech enhancement filter uses temporal smoothing of a Wiener filter calculation.

48. (original) The cabin of claim 40, wherein said speech enhancement filter uses frequency smoothing of a Wiener filter calculation.

49. (original) A movable vehicle cabin having ambient noise, said cabin comprising:

means for causing movement of said cabin, wherein at least a portion of the ambient noise during movement is a result of the movement; and

a cabin communication system for improving clarity of a voice spoken within an interior of said cabin , said cabin communication system comprising:

a first microphone, positioned at a first location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a first audio signal, the first audio signal having a first component corresponding to the ambient noise;

a second microphone, positioned at a second location within the cabin, for receiving the spoken voice and the ambient noise and for converting the spoken voice into a second audio signal, the second audio signal having a second component corresponding to the ambient noise;

a processor for summing the first and second audio signals to provide a resultant audio signal that is indicative of a detection location within the cabin relative to the first and second locations of said first and second microphones;

a speech enhancement filter for filtering the resultant audio signal by removing the first and second components to provide a filtered audio signal;

an echo cancellation system receiving the filtered audio signal and outputting an echo-cancelled audio signal; and

a loudspeaker for converting the echo-cancelled audio signal into an output reproduced voice within the cabin including a third component indicative of the first and second audio signals,

wherein said loudspeaker and said first and second microphones are acoustically coupled so that the output reproduced voice is fed back from said loudspeaker to be received by said first and second microphones and converted with the spoken voice into the first and second audio signals,

wherein said echo cancellation system removes from the filtered audio signal any portion of the filtered audio signal corresponding to the third component, and

wherein said speech enhancement filter comprises:

a first filter element that smooths a spectrum of the resultant audio signal over larger windows at higher frequencies in accordance with a mel-scale to provide a smoothed audio signal;

a second filter element that filters the smoothed audio signal with a causal Wiener filter to provide a Wiener filter result; and

a third filter element that performs at one of temporal and frequency smoothing of the Wiener filter result to provide the filtered audio signal.

50. (original) The cabin of claim 49, wherein said second filter element provides the Wiener filter result by taking a causal part of a weighted least squares Wiener calculation in which each weight is inversely proportional to an energy in a respective frequency bin.

51. (original) The cabin of claim 50, wherein said third filter element performs both temporal smoothing and frequency smoothing of the Wiener filter result.